STATUS AND CONSERVATION OF SENSITIVE HERPETOFAUNA IN THE MADREAN RIPARIAN HABITAT OF SCOTIA CANYON, HUACHUCA MOUNTAINS, ARIZONA

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ABSTRACT

We report on the results of a project to evaluate sensitive aquatic herpetofauna and initiate management efforts in Scotia Canyon of the Huachuca Mountains. The data gathered provide a basis for future management decisions and expand knowledge of natural history. The project focused on status of the mountain treefrog, Mexican garter snake, and non-native bullfrog. Status of leopard frogs and the tiger salamanders are also discussed. The report presents pertinent environmental data, describes methodology, reviews relevant literature, discusses project results and recommendations, and provides project data.

The riparian herpetofauna of Scotia Canyon was studied by us in 1980-1982 and again in 1993. Bullfrogs appeared and increased to great abundance in Scotia Canyon some time in the mid 1980s. With Parker Canyon Lake as the presumed point of initial introduction, bullfrogs have spread to the southwest flank of the Huachuca Mountains from Parker Canyon to Joaquin Creek and down into the San Rafael Valley. They are also present from the Fort Huachuca Military Reservation east to the San Pedro River and probably north to the Babocomari River.

Leopard frogs, which were uncommon in the 1980-1982 investigation, have been locally extirpated. They appear to have dwindled prior to the explosion of bullfrogs. No leopard frogs were observed anywhere along the southwest flank of the Huachuca Mountains in 1993. Our efforts to control bullfrogs suggest that Scotia Canyon is ideally suited for complete removal of bullfrogs and restoration of native leopard frogs.

A total of seven recent localities has been compiled for the mountain treefrog in the Huachuca Mountains and Canelo Hills. In Scotia Canyon, the mountain treefrog was present but did not reproduce in 1993 as it had in previous years. Scattered males were observed calling in 1993, however the ephemeral pond used for breeding did not fill until August 30.

The Mexican garter snake also persists. In 1980-1982, six yearlings and two small adults were observed including two emaciated individuals. In 1993, thirty young, two yearlings, and seven large adults were captured reflecting a population with relatively long-lived adults and low recruitment. Eighty-nine percent of yearlings and adults had broken tails in 1993 compared to none previously, probably reflecting predation attempts by bullfrogs. Bullfrogs undoubtedly constitute the majority of the diet of adult garter snakes. Any attempt to completely remove bullfrogs must include a program to restore native leopard frogs.

INTRODUCTION

The Madrean herpetofauna of Scotia Canyon and especially its sensitive elements have been the subject of recent research and management activities. It is the only assemblage in the United States of core Madrean herpetofauna including the mountain treefrog, Mexican garter snake, mountain kingsnake, and montane rattlesnakes. A total of twenty-five species of amphibians and reptiles were recorded in Scotia Canyon between 1980 and 1993, representing one salamander, five frogs, one turtle, eight lizards, and ten snakes. Recent concern for its sensitive riparian species stems from the extirpation of leopard frogs and invasion of non-native bullfrogs in the 1980s.

Objectives of the 1993 field project included: 1) population studies of the mountain treefrog and Mexican garter snake in Scotia Canyon to determine their status and to gather pertinent ecological data; 2) management of the local bullfrog population; 3) a survey of neighboring riparian habitats; and 4) an assessment of the habitat with management recommendations. The project was conceived to further scientific knowledge of the herpetofauna as well as to address the immediate threat posed by a recent invasion and explosion of non-native bullfrogs. This report includes the results of both the 1993 field work and our previous research in Scotia Canyon in 1980-1982.

No one has popularized the rich herpetofauna of the Huachuca range more than Carl Kauffeld (1957) who referred to it as the herpetological "holy land." Other treatments of the Huachuca area herpetofauna can be found in Johnson and Lowe (1979), Lowe and Schwalbe (1980), Stejneger (1903), and Woodin (1953). The area has also attracted many birders, botanists, and hikers. An excellent guide with many historical notes was recently authored by L. Taylor (1991).

SITE DESCRIPTION

The Huachuca Mountains are among the outliers at the northwestern periphery of the Sierra Madre Occidental. At elevations above 5000 feet, they are continuous with the Canelo Hills and Patagonia Mountains to the west and with the Sierra Manzanal to the south. Many plant and animal species exist there at the northern edge of their geographic range. Differences in composition of the herpetofaunas of the Patagonia, Huachuca, and Chiricahua mountain ranges attest to a history of expansion and contraction of species ranges that still eludes biogeographic analysis. A general biogeographic analysis of the Madrean herpetofauna of Mexico was provided by McCraine and Wilson (1988).

Scotia Canyon is situated on the southwest flank of the Huachuca Mountains (Maps 1 and 2). Although its slopes are generally warmer and drier than at similar elevations on the northeast flank, it has five ponds and three stretches of perennial streams to provide a rich mosaic of xeric and mesic habitats. These range in elevation from 5800 to 7900 feet.

Evergreen woodlands.--Mexican oak-pine woodland is the most widespread habitat type, varying from widely spaced trees to nearly closed canopy. It is composed, in various proportions, of alligator juniper, Mexican pinyon, and Emory oak. Open spaces are dominated by ground vegetation consisting of grasses, legumes, and composites. Variously scattered shrubs include manzanita, sumac, squawbush, smooth bouvardia, buckbrush, agave, yucca, sotol, and cacti. On some limestone soils, the dominant plant species are mountain mahogany, agave, grasses, and ferns.

Patches of open pine-oak forest occur in the shaded canyon bottom and some higher slopes in Scotia Canyon. These consist of Chihuahua pine, Apache pine, silverleaf oak, Arizona oak, and Mexican white pine along with many other woodland species mentioned above. There is less ground vegetation and more leaf litter than in the woodlands. This habitat type is more or less intermediate between woodland and forest of the Upper Sonoran and Transition Life Zones.

Riparian habitats.--Along streams are typical elements of the Riparian Woodland Formation such as sycamore, walnut, willow, cottonwood, Arizona grape, poison oak, mixed with many of the previously mentioned woodland species. Scouring rush, penstemon, and dense grasses occupy most of the banks. There are four permanent ponds in Scotia Canyon. Whereas the lower pond is along the stream, the other three are impounded springs. A fifth, ephemeral pond is used as a breeding site by the mountain treefrog.

Three impounded springs are associated with cienega vegetation consisting of spike rush, sedge, bulrush, cattail, watercress, and some willow and cottonwood. Between the springs and ponds are several meters of open cienega with deep organic sediments that are permanently saturated. Although small in size, these areas agree with the definition of cienega given by Hendrickson and Minckley (1985). Above the springs are mesic, closed canopy oak groves. This association consists of Arizona oak, silverleaf oak, Emory oak, and Arizona madrone. It has a thick layer of leaf litter and few ground level plants.

Climate.--In Arizona, the Mexican Oak-pine Woodland lies within the Upper Sonoran Life Zone (Lowe 1964). Long term climatologic data are available for Canelo and Coronado National Memorial (Sellers et al. 1985), the nearest stations in the Evergreen Woodland Formation. Annual distributions for temperature and precipitation at these two stations are provided in Figs. 1 and 2. Assuming a mean annual temperature of approximately 14°C (57°F) and mean annual PPT of approximately 500 mm (20 inches), the site would lie within the Warm Temperate, Lower Montane Dry Forest Life Zone of Holdridge (1967).

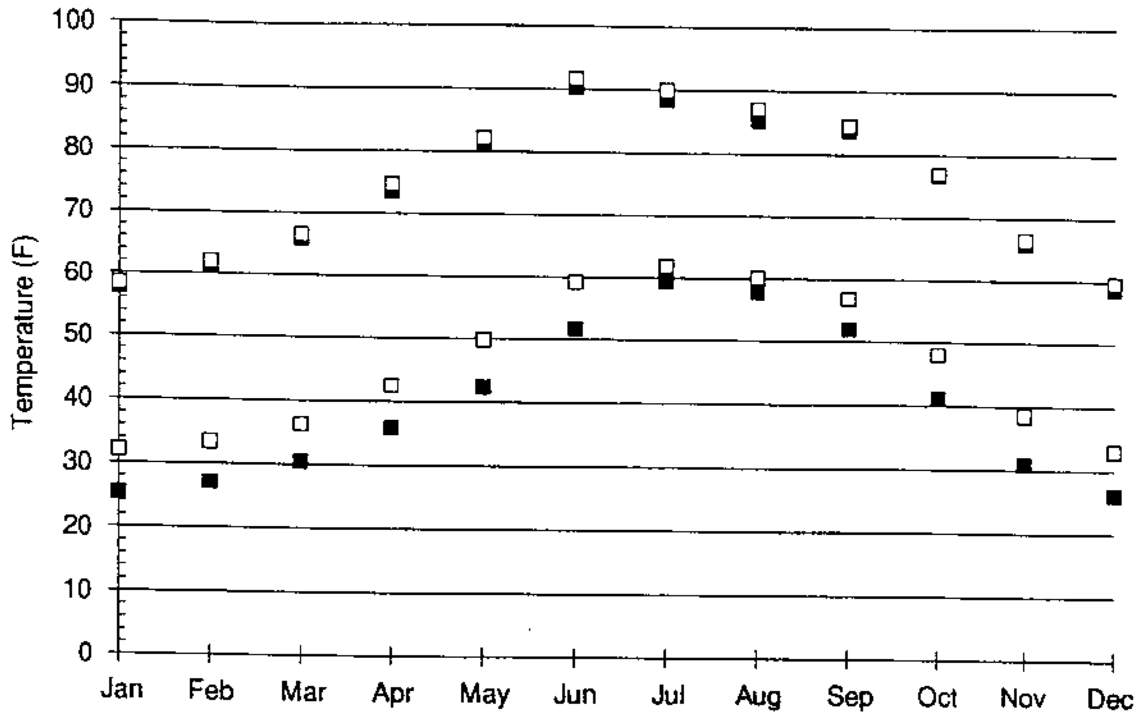


Figure 1. Average daily maximum and minimum temperatures by month at Canelo and CNM.

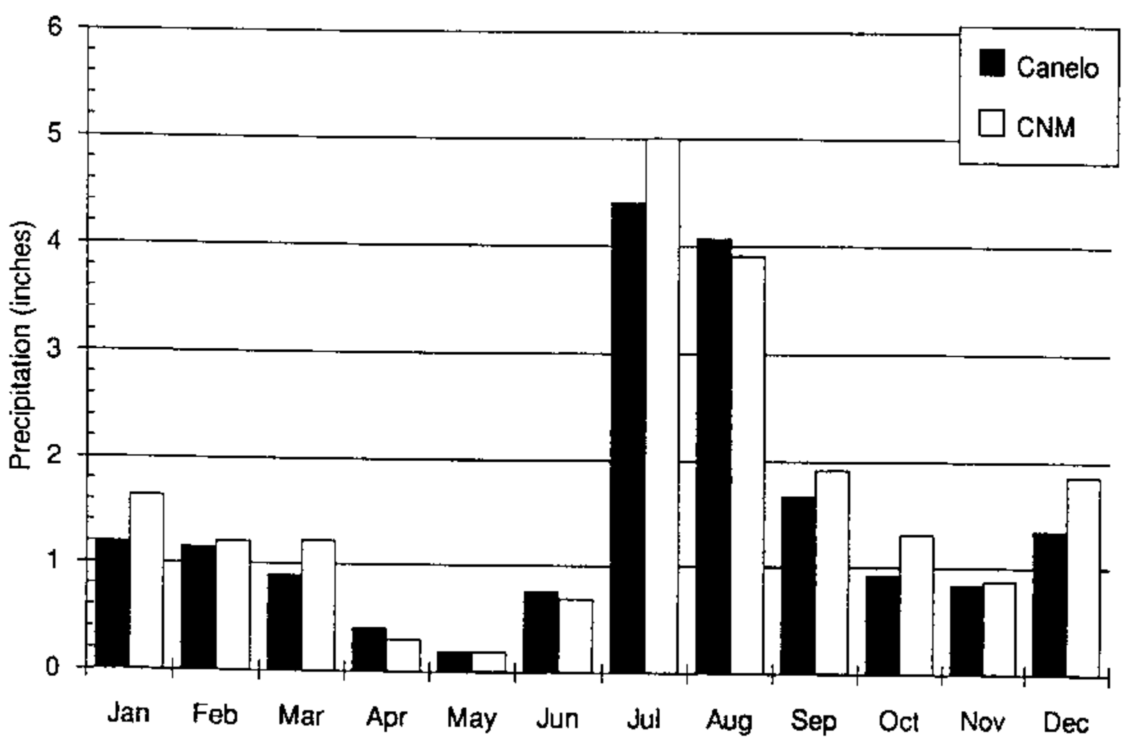


Figure 2. Average monthly precipitation at Canelo and Coronado National Memorial.

METHODS

Personnel associated with the University of Arizona Herpetology Collection have conducted field investigations in Scotia Canyon since the 1950s. More intensive research activities occurred from 1980 to 1982. This report contains the results of the current project and includes previous results both for comparison and for a more robust data set.

In 1993, we carried out field work for the current project. Between June 30 and September 13 of 1993, a total of 50 person days were spent in the field over 42 calendar days. Time not used to check traps and process captures was devoted to searching riparian (80%) and upland (20%) habitats for the three target species as well as for leopard frogs and tiger salamanders. All traps, ponds, and stream above the lower crossing were checked daily, and adjacent terrestrial habitats, irregularly as time permitted. Searches were accomplished by walking slowly, watching and listening for animals, looking in water for animals, larvae, and egg masses, looking beneath cover, and occasionally using a dip net and seign when water was turbid. Neighboring canyons were investigated similarly once during 1993.

Voucher specimens were collected in the 1980s and are deposited with the Department of Ecology and Evolutionary Biology, University of Arizona. Specimens were fixed in 10% formalin, rinsed in water, and preserved in 33% isopropanol for amphibians and 55% isopropanol for reptiles. Amphibian larvae were preserved in 20% formalin.

Daily temperatures were monitored at the Peterson Ranch with a max-min thermometer and precipitation was monitored with a rain gauge filled with 10 mm mineral oil layer to prevent evaporation. The data are presented in Figs. 3 and 4.

Species lists and basic data for sensitive taxa are tabulated and presented in the appendices. These lists were based only on our field observations during the study and are intended to provide a valuable environmental context as well as to stimulate further interest. Primary literature was located by consulting the Zoological Record and Biological Abstracts (see literature cited). Virtually all literature, including many anecdotal accounts can be found in the Synopsis of the herpetofauna of Mexico, volumes 1-7, by Smith and Smith (1973-1993). For this project, we reviewed only those references that were relevant to the ecology and status of the mountain treefrog and Mexican garter snake.

Species specific field procedures are described below.

Mountain treefrog.--In 1993, we recorded data on the date, time, and location of male treefrogs that were vocalizing. In previous years with abundant treefrog activity, we recorded the following additional data: activity, size, sex, and color pattern. Snout-vent length (SVL) was measured to the nearest mm with a plastic rule; mass was determined to the nearest 0.01 or 0.1g with a 5g or 10g Pesola® spring scale. Samples of larvae were collected periodically; we measured SVL, vent-tail length (VTL), and maximum tail fin height to the nearest 0.1 mm using

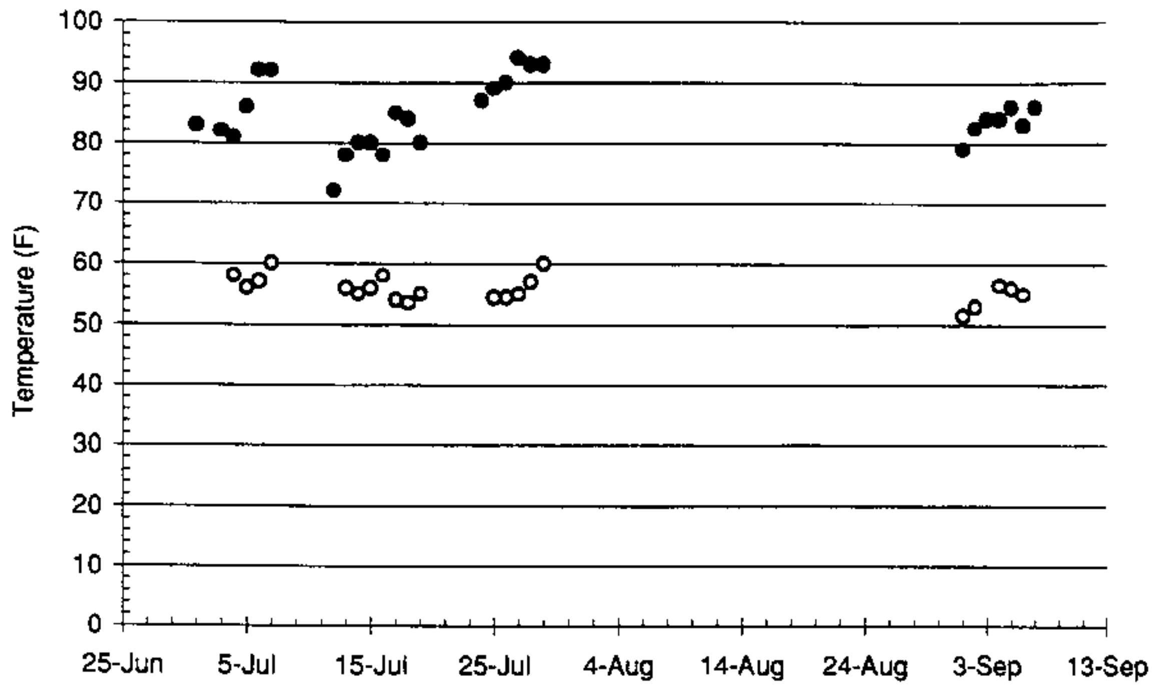


Figure 3. Daily maximum and minimum temperatures at Scotia Canyon in 1993.

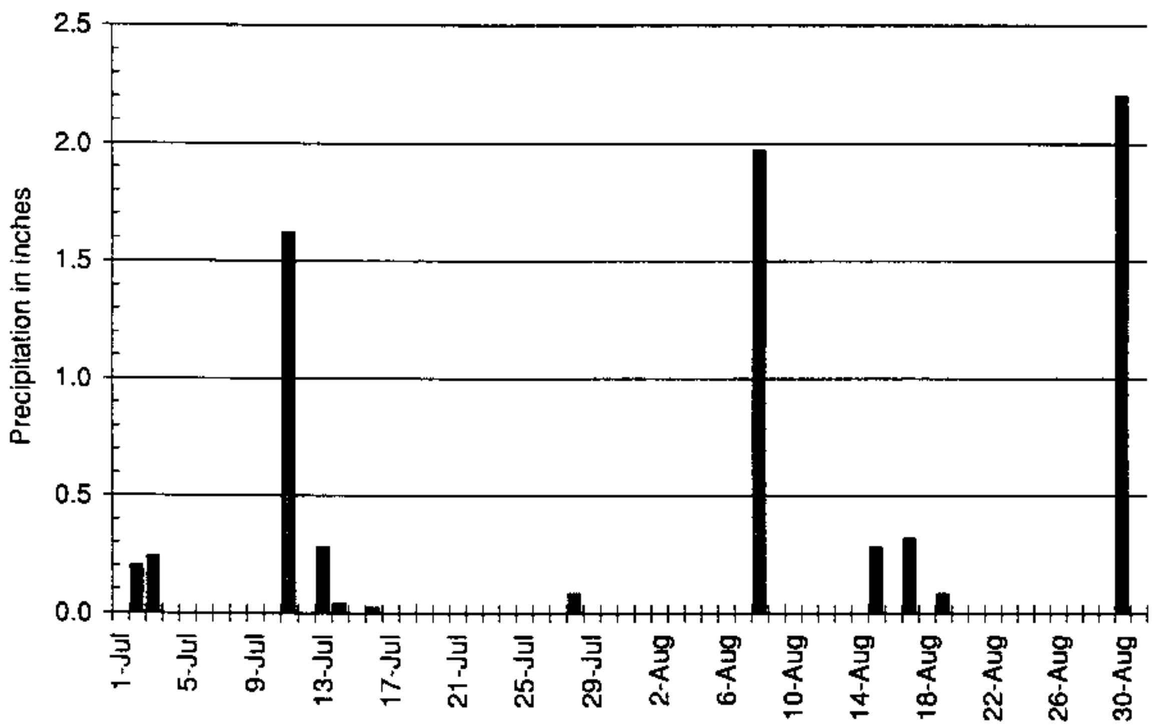


Figure 4. Precipitation in Scotia Canyon during July and August 1993.

dial or digital calipers; mass was determined to the nearest 0.001 g on an analytic balance. A dissecting scope was utilized to determine reproductive condition and clutch size in selected females.

Mexican garter snake.--Garter snakes were caught by trap and by hand while they were basking, foraging, or resting beneath cover. We recorded the following data: date, time, location and activity, food items (occasionally regurgitated), size, sex, injuries, and scutellation. Snout-vent and vent-tail lengths were measured to the nearest mm with a metal tape; mass was measured to the nearest 0.1 to 10g with spring scales of 10g, 50g, 300g, and 1000g capacity; a set of five snake sexing probes was used to determine sex of snakes; when possible, body and ambient temperatures were recorded to the nearest 0.1 °C with a Cloacal® rapid adjusting thermometer.

Snakes were marked by removing selected subcaudal scales with hang-nail clippers and treated with Neosporin® antibiotic ointment. Notes on scutellation recorded counts and anomalies of supralabials (and their contact with the ocular), postoculars, anterior temporals, and posterior temporals. These notes were used to confirm identity of recaptures.

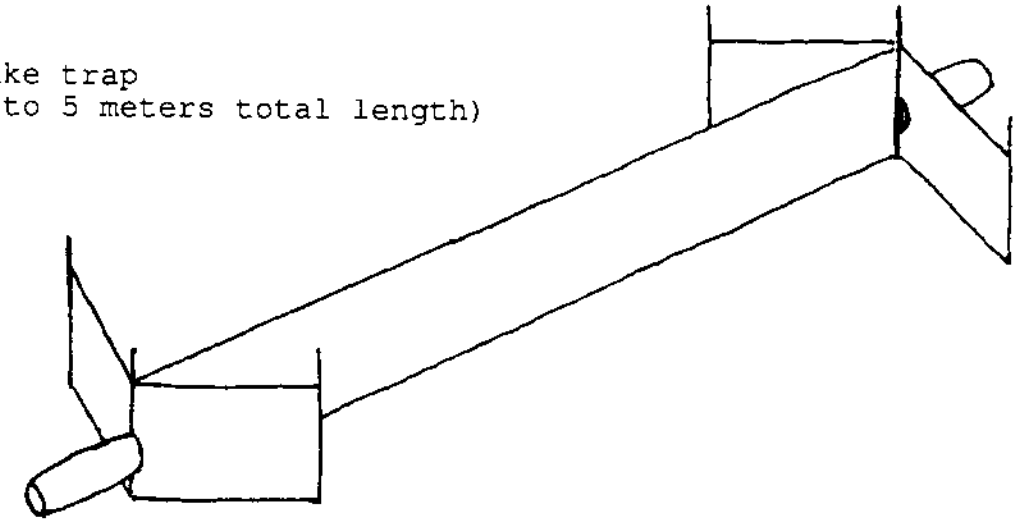
Bullfrog.--Bullfrogs were taken by hand, gig, trap, and pellet or BB gun. We focused on bullfrog removal during the first week and then less intensively throughout the field season as frogs diminished in abundance. We made a special effort to remove large bullfrogs at all times.

All frogs were weighed and measured; most of those measuring greater than 100 mm SVL or 100 g were sexed and examined for reproductive condition by dissection. Most frogs (unless removed from traps) were examined for stomach contents in order to determine diet.

Snake traps.--Six snake traps (Fig. 5) were deployed in the study area for a total of 144 trap days. Except for the first week of field work, traps were distributed evenly between the upper pond and lower pond, where most garter snakes had been sighted. During the first week, one trap was deployed at the middle pond. Each snake trap (Rosen and Schwalbe, 1988) consisted of a 3.5 to 4.5 meter length of drift fence (36 inch wide hardware cloth with 1/8 inch mesh), supported at each end by a metal fence stake. To each end was attached a funnel trap (modified minnow trap) with a 30 mm opening at the funnel apex on the fence side. The funnel traps were set up to one half submerged in water. Traps were arranged with the drift fence at a 45 to 90° angle to the shore with one trap at the shore line.

To discourage snakes from wandering around the trap, wings were attached to each funnel. These consisted of a 72 inch length of 36 inch nylon window screen with a hole cut below the center to fit the base of the funnel. The ends were attached to stakes (lathing) and planted at a 45° angle back towards the fence.

Snake trap
(4 to 5 meters total length)



Turtle trap
(1.5 meters total length)

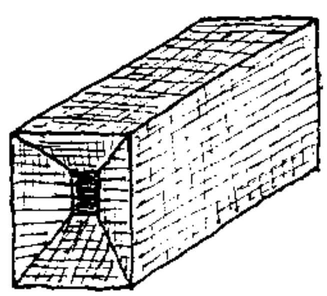


Figure 5. Configurations of snake and turtle traps used.

Turtle traps.--Four turtle traps were deployed in order to capture bullfrogs and Sonoran mud turtles. These traps were constructed from 48 inch wide poultry fencing with a one inch mesh. They measured 24 X 24 X 48 inches. A funnel (pyramid) at one of the small ends tapered to an interior opening of six inches. The traps were placed with a far corner well above water to permit breathing while the funnel end was submerged to discourage waterfowl and mammals from entering.

ECOLOGY AND STATUS OF THE MOUNTAIN TREEFROG

For the mountain treefrog, *Hyla eximia* Baird, a complete listing of synonyms was provided by Duellman (1970). Other works exploring systematic relationships include Blair (1960), Jameson et al (1966), Maxson and Wilson (1974), and Taylor (1938). Descriptions and/or aides to identification have appeared in Altig (1987), Behler and King (1979), Bogert (1958), Stebbins (1954 and 1985), and Wright and Wright (1949).

Early references to the mountain treefrog in the Huachuca Mountains were made by Stebbins (1954) and Jameson et al (1966). So far, Duellman (1970) provided the most comprehensive list of localities throughout the range of the species. He examined 2209 specimens. More recently, Painter (1986) reported on the first specimens collected in Colima, Mexico.

Data on habitat, reproduction, and diet were provided by Chapel (1939). Additional ecological notes have appeared in Korky and Webb (1991), Martin (1958), Van Devender and Lowe (1977), and Zweifel (1961). Sredl and Collins (1991) experimented with predation on tadpoles by larval tiger salamanders. The mountain treefrog was nominated the State Amphibian in 1985 (Anon. 1985).

From a herpetological standpoint, the mountain treefrog was rediscovered in the Huachuca Mts in 1980. The first specimen was collected in Scotia Canyon in August of 1980 (UAZ No. 44743). Older specimens were reported from Garden Canyon Road and 1.5 miles northwest of Miller Peak (Jameson et al 1966) and we received unverified reports of sightings in Miller Canyon in the 1970's. Since 1980, we have also received specimens from Turkey Creek Ranger Station and from Huachuca Canyon at 6,600 feet as well as notes on observations from Oversite Canyon, Lone Mountain Canyon, and a tributary to Scotia Canyon. Recent observations are located on Map 3.

We visited Scotia Canyon in the summers of 1980-1982, 1989, and 1993. Reproduction was observed in all but the last year. In 1993, the breeding pond utilized by mountain treefrogs was not filled until August 30. Although males called from various locations around the site in July and early August, no choruses formed and no reproduction occurred. We looked for evidence of reproduction in the mountain treefrog at other known localities in 1993 and found none. Most of the natural history information presented below derives from field work conducted 1980-1982.

Activity patterns and microenvironments.--In the vicinity of the Peterson Ranch site, mountain treefrogs were observed from late June to early October during our studies. The overall activity period probably does not extend much more into the fall because of dry and cold conditions. We have one report of a mountain treefrog observed in the spring of 1993 in Lone Mountain Canyon (D. Parizek, pers. com.).

In summer, adult treefrogs preferred the more mesic oak groves and seeps during the drier parts of the day. The frog blends in well with the mosaic of new green foliage and brown litter and rock. We also found adult and young treefrogs beneath logs and rocks in nearby moist areas. At dusk, adult frogs converged at the breeding pond and many remained there until dawn. Daytime dispersal away from the breeding pond may serve to reduce the risk of predation.

In fall, froglets were especially abundant in the marshy areas where water seeps in and out of the cienega-like pond just NE of the breeding pool. We have been unable to verify the location of overwinter sites. We believe they may be using deep fissures in the limestone outcrops along the nearby arroyo. Overwintering *H. eximia* were reported to seek shelter in bromeliads and beneath rocks in Mexico (Duellman, 1970).

Breeding sites and breeding activity.--Although five ponds and two permanent streams were available, we found the mountain treefrog only breeds in one shallow rain pool. This pond, when full, measures 23 X 14 meters and is 50 cm deep in the center. It has been observed to be completely dry on various dates from May through August, although in some years it appears to retain water throughout the year. Mountain treefrogs have also been observed in breeding choruses in a pool below the pond in a lower tributary of Scotia Canyon (D. Hardy and F. Wilson, pers. com.) and in a deep pool along Turkey Creek near Canelo (see Map 3).

We observed adult males calling as early as July 1 and as late as August 6. Isolated males called infrequently throughout the daylight hours from various points within 200 m of their breeding pond, usually on the ground. During periods of low humidity, they were more likely to call from the more mesic oak groves and seeps than the drier woodlands. Calling was sometimes triggered by bird calls from trogons, jays, or ravens.

Adults converged at the breeding pond following sunset. Throughout the night, choruses proceeded intermittently involving from few to over thirty individuals. Chorusing stopped abruptly following a lightning flash or motion of the observer, and then resumed gradually after about twenty seconds. It was sometimes triggered by talking and also became noticeably more intense when a light rain began. Males called mostly from the shore and from shallow water, often clinging to emergent grasses and sedges. Amplexing pairs of frogs were observed at night and shortly after sunrise. Most adults, however, dispersed and remained away from the breeding pond during the daylight hours.

Eggs and development.--Eggs were observed near the edge of the pool, singly or in clusters of up to fifteen, attached to debris or vegetation 2.5 to 7 cm below the water surface. We dissected one female of 37 mm SVL, collected 24 July 1982. It contained 826 bicolor, brown and cream eggs ranging in diameter from 0.8 to 1.2 mm. Numerous unicolor, white or gray-brown eggs ranged in diameter from very minute to 0.6 mm. Clutch sizes for three North American *Hyla* spp., compiled by Duellman and Trueb (1986), range from 650 to 900.

The duration of various stages in the life cycle is difficult to assess. Based on first appearances we estimate that eggs hatch approximately one week following fertilization and the larvae transform into froglets at least one month later. We observed tadpoles as early as July 20 and as late as September 28. Fully transformed froglets have been observed as early as September 6.

Developing frogs increase in mass by a factor of 100 from hatchling to newly transformed froglet (from 0.002 to 0.2 grams--Fig. 6). Prior to returning to the breeding pond as adults, the froglets evidently must increase in mass by a factor of at least 12.5 (e.g. from 0.2 to 2.5 grams). This suggests that there is a significant period of activity and growth away from the breeding site that we did not observe in our studies.

Mortality.--We observed Mexicans garter snake eating larval and adult treefrogs. We also observed waterbugs (*Lethocerus*) eating eggs, larvae, and adult treefrogs. In 1980 to 1982, we regularly observed leopard frogs, Mexican garter snakes, and

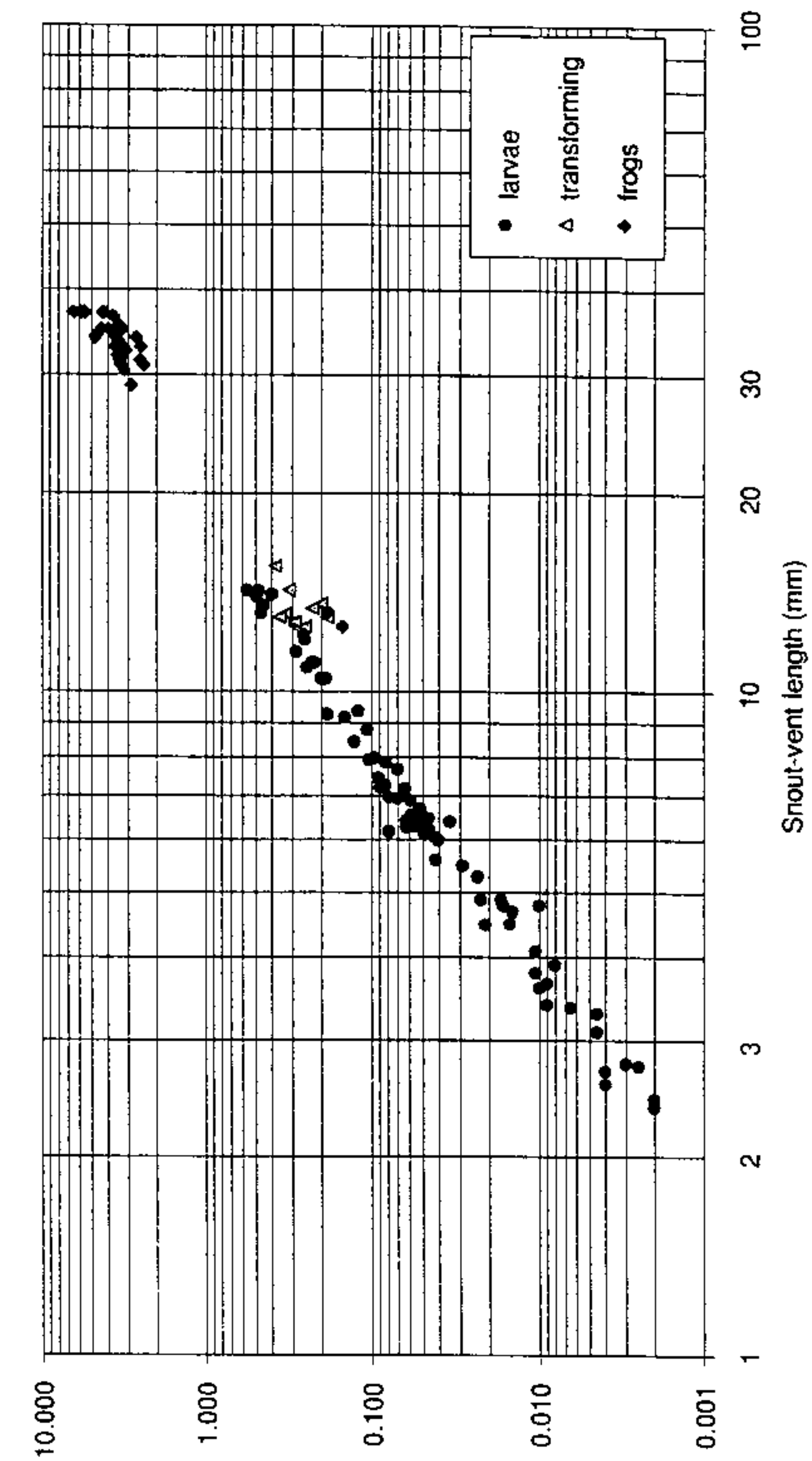


Figure 6. Mass-length relations in the mountain treefrog at various stages in the life cycle at Scotia Canyon.

occasional black-necked garter snakes at the choruses. It is likely that the Mexican garter snake is a significant predator on breeding frogs.

Ecological status.--At present, the mountain treefrog continues to persist in the Huachuca Mts. The failure of reproduction in 1993 is alarming and the Scotia Canyon population should be monitored in the future. Such setbacks, due to climatic events, are natural and probably rarely result in local extinctions unless repeated over several consecutive years.

The effects of the recent invasion and explosion of bullfrogs could be more severe either alone or in combination with climatic stress. The mountain treefrog's vulnerability to predation by bullfrogs is partly ameliorated by the same causal factor that led to its reproductive failure in 1993. It uses an ephemeral breeding pond. Desiccation of this pond during the pre-monsoon drought would kill any bullfrog larvae and at least temporarily drive away adults. The persistence of mountain treefrogs may ultimately depend on the availability of ephemeral breeding ponds in the appropriate habitat.

Taxonomic status.--Mountain treefrog populations of the northwestern part of the range (Arizona, New Mexico, and Chihuahua) were formerly recognized as a distinct species (*Hyla wrightorum* Taylor, 1939) and later as a subspecies (*H. eximia wrightorum* Schmidt, 1953). Duellman (1970) considered them all to be conspecific, with the northern forms differing somewhat by being slightly larger and more robust with proportionately longer limbs. Although the mating call of Apache Co. frogs had a slightly higher fundamental frequency, it was within the range of those sampled from Mexico. Duellman stated that there were no distinctive morphologic characters.

The mountain treefrog (*H. eximia* Baird, 1854) is currently recognized as being monotypic. It is still unclear as to whether the northern populations deserve recognition as a subspecies distinct from the remaining populations in Mexico. We tentatively concur with the present systematic status and recommend that studies be undertaken to determine the nature and extent of geographic variation.

We have begun to examine morphometric variation in order to identify any diagnosable characters for the two regions. Zweifel (1961) reported an average larval tail fin height to body length ratio of 0.728 for nine larvae (stages 35 to 41) from Mexico and 0.558 for 14 larvae from the White Mts. We found a mean of 0.633 for ten similar sized larvae measured from the Huachuca Mts., perhaps an indication of clinal variation in this character.

ECOLOGY AND STATUS OF THE MEXICAN GARTER SNAKE

The Mexican garter snake, *Thamnophis eques* (Reuss), has seen several historical changes in nomenclature (see Smith 1951, and Webb 1980). The species was first described by Reuss (1834), however Boulenger (1893) incorrectly applied the name "eques" to material including the black-necked garter snake as did Woodin (1950). Smith (1951) recognized the error and resurrected the name *T. cyrtopsis* for the black-necked garter snake and *T. eques* once again became applied to the Mexican garter snake. Workers compiling localities and literature on these species should be aware of the possible confusion and verify the identity of all material. Good descriptions have appeared in Shaw and Campbell (1974), Stebbins (1954 and 1985), and Wright and Wright (1957).

Distributional information has been provided by Bradley (1986), Tanner (1985), Dominguez et al (1977), Van Devender and Lowe (1977), Lowe (1964), and Conant (1963). Many of these also provided notes on habitat and morphological variation.

Ecological studies focusing on diet and foraging were reported by Macias and Drummond (1988) and Drummond and Macias (1989). Additional reports pertaining to conservation status and distribution were provided by Fitzgerald (1986), Rosen and Schwalbe (1988), and Schwalbe and Rosen (1988).

In brief, our results suggest that the structure of the Mexican garter snake population in Scotia Canyon has changed since the early 1980s. At the time when leopard frogs were in decline, garter snakes appeared to be dying of starvation and few large individuals were observed. In 1993, we observed a greater proportion of large adults and a lower proportion of yearling and small adults. We believe this is due to the availability of bullfrogs as prey for larger snakes and predation on small snakes by larger bullfrogs. In 1993, most snakes exhibited broken tails, whereas none did in the early 1980s.

Distribution and movement.--The distribution of Mexican garter snakes in Scotia Canyon appears to be limited to aquatic habitats or cover sites within a few meters. In 1993, we observed garter snakes in the main upper and lower ponds. Many young of the year were apparently dispersing upstream from the lower pond throughout the later part of the season. All stream captures in Appendix B were between the lower pond and 180 meters upstream. The two identified as A2 and A3 are preserved specimens from the Peterson Ranch site (University of Arizona--UAZ 44306 and 44285).

In previous years we regularly observed garter snakes at the ephemeral pond used by mountain treefrogs. No frogs or snakes appeared there in 1993 and the pond was not filled by rains until August 30. Also in previous years, we observed garter snakes and leopard frogs in the middle pond. Only a few bullfrogs were observed there in 1993. So far, we have not observed the Mexican garter snake in Scotia Canyon below the lower pond, although one black-necked garter snake was seen there twice in 1993.

The Mexican garter snake is known elsewhere in the region from Parker Canyon Lake and the Santa Cruz River in the San Rafael Valley, to the south and west. It is also found in Turkey Creek and the Babocomari and San Pedro Rivers, mainly to the north and east (Rosen and Schwalbe 1988).

Activity patterns and microenvironments.--Mexican garter snakes are active both diurnally and nocturnally. We observed them foraging at all hours when prey were available. Limits to activity may be determined primarily by ambient temperatures. Snakes were active at air temperatures ranging from 14.8 to 27.8°C (N=13), surface temperatures from 19.0 to 31.5°C (N=13), and water temperatures from 22.1 to 22.5°C (N=4); deep body temperatures ranged from 19.4 to 28.7°C (N=6).

Snakes were found foraging in water, on shore, and in vegetation. Individuals were observed basking on shore or more often in vegetation overhanging water. Few snakes were found beneath cover (sheet metal, board, or rock) within a few meters of water. One hole in compacted soil, two meters above the lower pond was frequented by several snakes.

The trap data appear to provide some insight into behavior. Fifteen of eighteen (83%) young were captured in shallow end traps compared to seven of nine (78%) larger snakes that were captured in deep end traps (χ^2=9.609, P<.005). Similarly, yearlings and adults were found only in ponds, whereas eight young (27%) were found along the stream.

Diet.--The diet of Mexican garter snakes in Scotia Canyon, as determined from direct observations of feeding and of animals regurgitating immediately after capture, included larval and adult bullfrogs up to 125 mm SVL, larval tiger salamanders, mountain treefrogs, and earthworms. Earthworms were abundant around ponds and along the stream above the lower pond which was frequented by young-of-the-year garter snakes. Larger garter snakes clearly enjoy a far more abundant and continuous food source (bullfrogs) now than they did in the early 1980s.

Reproduction.--Neonates were first observed at the upper pond on July 4 and at the lower pond on July 15. Neonate-sized snakes (i.e., less than 200 mm SVL) were captured as late as July 29; however, we were not present from July 30 to August 15.

No neonates were captured in 1981-1982. Although sampling methods were different (we did not use traps in 1981-1982), it is unlikely that they were overlooked unless at very low density. It appears that reproduction was greatly depressed in 1981-1982 and this is consistent with the observation of dead snakes (see below) and scarcity of prey.

Mortality.--In late July and early August of 1981 and 1982, a neonate black-necked garter snake and a yearling and an adult Mexican garter snake were found dead in the ephemeral pond used by breeding mountain treefrogs. All snakes appeared to have starved. The small adult female was dissected and found to have an empty stomach and intestine. No injuries or parasites were noted, and fat bodies were barely visible. The garter snakes captured in 1981-82 exhibited an overall pattern of lower body mass in proportion to SVL compared to the 1993 sample (Fig. 7).

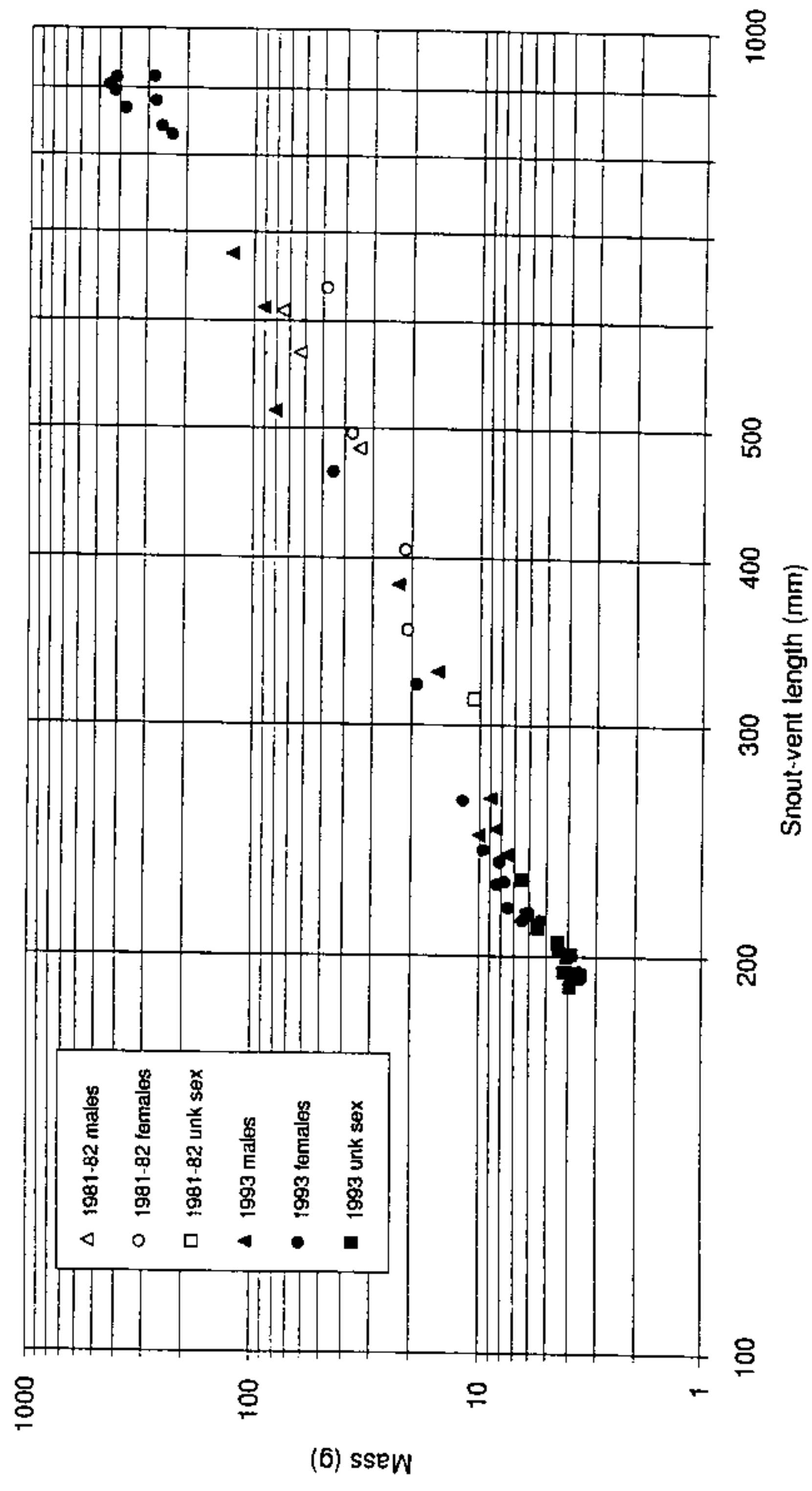


Figure 7. Mass-length relations for Mexican gartersnakes at Scotia Canyon. Note greater size of adult females.

We believe that garter snakes died in the early 1980s because of the decline and disappearance of leopard frogs. All of the snakes observed in the early 1980s were yearlings and small adults. Perhaps yearlings could subsist on earthworms. Mountain treefrogs would have only been present during the summer at the Peterson Ranch site. Snakes at the lower pond may have been sustained by tiger salamanders.

No dead or emaciated snakes were observed in 1993. Bullfrogs have clearly become the main prey of adult garter snakes. We have not observed predation on small snakes by large bullfrogs although this seems highly probable in light of other observed injuries.

Injuries.--The most obvious injuries in Mexican garter snakes are loss of some portion of the tail which is permanent. Eight of nine (89%) adults and yearlings sampled in 1993 had broken tails compared to none of seven sampled in 1981-1982 (χ^2=12.444, $P<.0005$). The incidence of tail breaks clearly reflects the invasion and explosion of bullfrogs in Scotia Canyon in the 1980s. Many of the snakes had tails that appeared to have been pinched dorsoventrally as if they had been grasped by a bullfrog.

Most of the adults and yearlings captured in 1993 possessed conspicuous patches of dark scars dorsally on the neck and anterior body. We were unable to conclude whether these are the result of abrasion, sunburn, or some biological agent.

Population structure.--In 1993, we captured seven adults, two yearlings, and thirty young of the year. The ratio of adults to yearlings contrasts significantly with the two adults and six yearlings found in 1981-1982 (χ^2=4.735, P<.05). This pattern suggests that although adults have been living longer, reaching greater size, and producing many young, recruitment has been low due to high mortality of young snakes. Recruitment was found to be virtually absent for the Mexican garter snake population at San Bernardino National Wildlife Refuge (Schwalbe and Rosen 1988), a site where bullfrogs are abundant.

Ecologic status.--The present scarcity of intermediate sized snakes and the incidence of tail breaks suggest that bullfrogs are having a detrimental effect on garter snakes. Yet large snakes depend on bullfrogs as their primary food source. Perhaps the survival of small snakes could be enhanced by creating patches of safe habitat. For example, the stream above the lower pond was not used by large bullfrogs (see below); it could be made more complex structurally by planting rocks and emergent vegetation to provide habitat for more small snakes.

The history of local garter snake populations is perhaps unknowable. Some may be recent founders whereas others may be relics. It should nevertheless be possible to determine the viability of local populations and shed light on the nature of larger scale (i.e. metapopulation) dynamics (Holm et al. 1993). The time scale on which there is migration between populations and how it has been affected by human activities are unknown but of great importance to the conservation biology of this species.

ECOLOGY AND MANAGEMENT OF THE BULLFROG

John Carr's now famous photograph (in Schwalbe and Rosen 1988) of a bullfrog consuming a Mexican garter snake at Parker Canyon Lake in 1964 is among the earliest accounts of bullfrogs in the region. Bullfrogs were not observed in Scotia Canyon in 1980-1982. Few adults and several to many juveniles were sighted in 1989, and by 1992 all aquatic habitats appeared to be overrun with bullfrogs.

Distribution and microenvironments.--In Scotia Canyon, bullfrogs were found in all aquatic habitats from the Peterson Ranch down to the AZ Trail crossing. They were also found in aquatic habitats in nearby canyons (Map 4). Bullfrog larvae were only found in open ponds. During summer rains, isolated transformed individuals were found on roads up to a half mile from the nearest aquatic habitat.

Perhaps by attrition in less optimal home ranges, bullfrogs seem to prefer dense vegetation on shore with hollow spaces in which they can move about. Frogs were difficult to remove from these areas. Those inhabiting streams would seek refuge in underwater, subterranean cavities, sometimes greater than arm's length.

Reproduction and development.--The bullfrog breeding season commences with full force in April and declines in intensity steadily into the early summer. Female bullfrogs dissected in the summer of 1993 exhibited egg masses ranging from 1) pink with a satiny texture, 2) cream colored and fine-grained, 3) yellow and coarse-grained, 4) yellow and mature black eggs, to 5) mature black eggs. Only females of SVL greater than 110 mm contained mature, black eggs (see Figs 8 and 9).

Some proportion of tadpoles transform late in their first summer at SVLs of 40 to 45 mm, while the remainder extend development overwinter and transform early in the following summer at SVLs of 55 mm or more.

Population structure.--The sex ratio of large bullfrogs (SVL>100mm, or mass>100g) was exactly 50:50 with 32 females:32 males. Most bullfrogs inhabited the two largest ponds (upper and lower ponds) and less than ten percent were captured in streams. None of the thirty-seven larger frogs of 125 mm SVL or greater was captured in streams.

Diet and feeding.--Bullfrogs in Scotia Canyon eat a wide variety of small animals (Fig. 9). The most common items appearing in dissected frogs were various beetles, waterbugs, and dragonflies. During the summer we were impressed by the abundance of beetles at the site. At dusk, they take flight and the air hums with thousands of the insects. We saw and heard bullfrogs

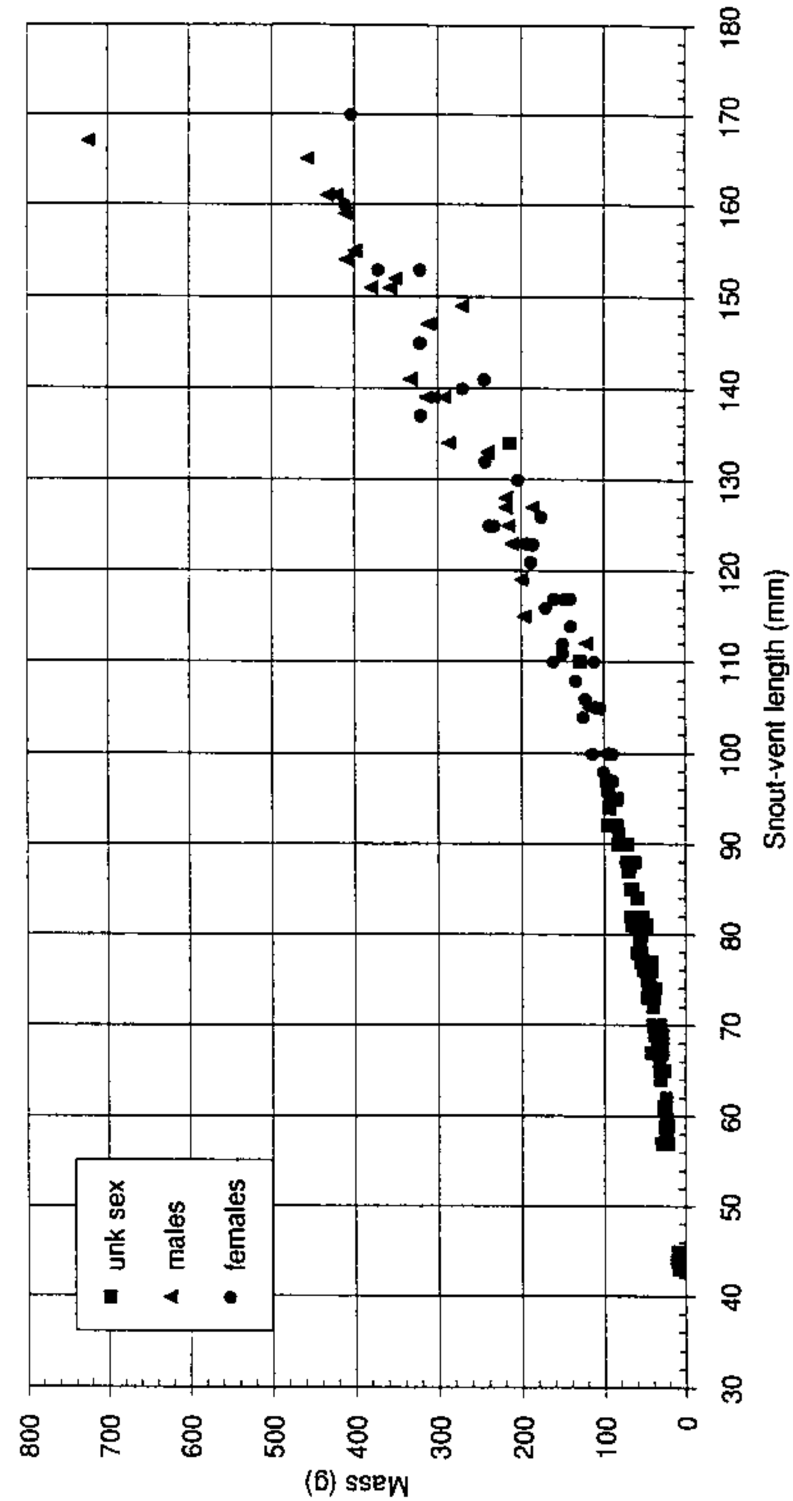


Figure 8. Mass-length relations of bullfrogs at Scotia Canyon.

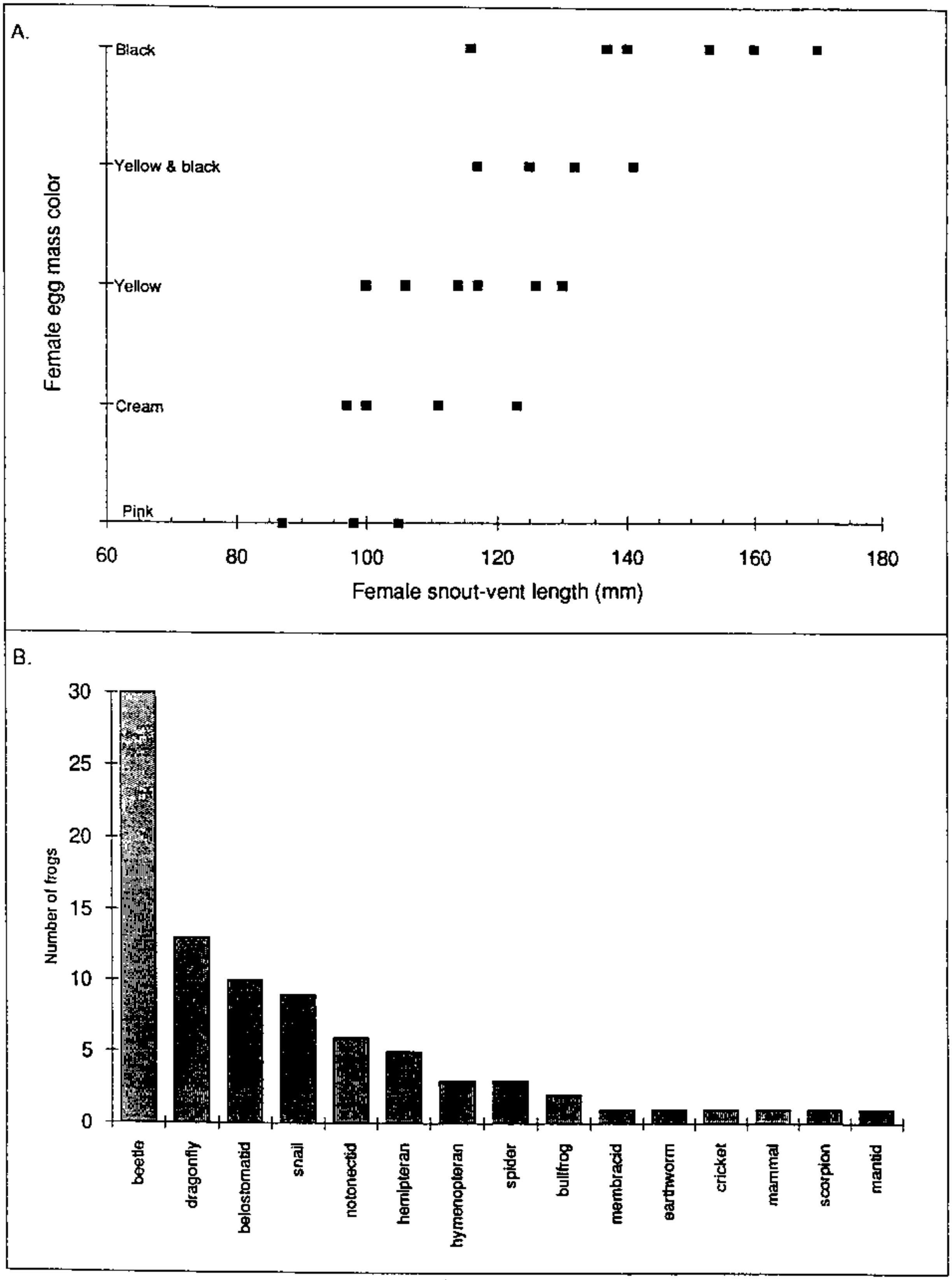


Figure 9. A. Reproductive condition of female bullfrogs in Scotia Canyon, summer 1993.
B. Prey species recovered from dissected bullfrogs in Scotia Canyon, summer 1993.

leaping at these prey. It was clearly their peak foraging time.

Only two bullfrogs and one small mammal were recovered from the 79 dissected frogs. Bullfrogs are opportunistic feeders and will eat anything they can swallow. Insect were the most abundant prey available. The abundant insect prey are invariably converted into an abundance of bullfrogs.

Management of the bullfrog.--One hundred and sixty two bullfrogs were removed from Scotia Canyon in 1993. Of these, 87% were taken in July and 13% in August and September. Of the July frogs, 42% were over 100 mm SVL compared to 14% in Aug-Sep. A final September check, although subjective, revealed three adults, twenty two juveniles, and many larvae remaining.

Seasonal drying of the ephemeral pond appears to be necessary to rid it of bullfrogs and other potential predators on the mountain treefrog which breeds there. A PVC pipeline formerly carried water down from the Peterson Ranch site towards Sunnyside. It was leaking directly into this pond in 1989. We do not know if this affected reproductive success for the mountain treefrog by supporting more bullfrogs.

In 1993, the water pipeline was leaking into the stream 460 meters above the lower pond. Although its impact was obviously less critical than in 1989, we reconnected the pipeline in order to discourage any bullfrog migration that may result from the extra streamflow.

SURVEY OF NEIGHBORING RIPARIAN HABITATS

We observed bullfrogs in permanent water habitats in Parker Canyon Lake, and Garden, Scotia, Sunnyside and Sycamore Canyons. They appear to be absent in Turkey Creek to the northwest and in Lone Mt, Bear, Cave and Copper Canyons to the southeast (refer to maps for locations). The following locations are treated from northwest to southeast:

Northwest--Bullfrogs absent

Turkey Creek.--We checked only the portions of Turkey Creek above Canelo. They appeared to be free of bullfrogs at the time. A pond is located at the headwater (T23S, R19E, Sec 6, NW¼). It had one or more kinds of unidentified pond fish. We were unable to locate any mountain treefrogs in the vicinity of Canelo, although they had been previously collected near the Turkey Creek Ranger Station.

Central--Bullfrogs present

Collins, Parker, and Merritt Canyons.--These three canyons all drain into Parker Canyon Lake and were expected to have bullfrogs. They were, however, mostly dry during our searches this summer. We did not observe any aquatic herpetofauna in the few natural pools and artificial ponds we encountered northeast of SR 83. These canyon bottoms seem to provide natural corridors for the movement of snakes. In 1993, we encountered one Sonoran whipsnake, one gopher snake, two blacktail rattlesnakes (one dead), and one rock rattlesnake (dead) on SR 83 at the crossings for these three canyons.

Scotia and Garden Canyons.--There is a tributary to Scotia Canyon situated to its west side. Along this canyon is a pond (T23S, R19E, Sec 17, SE¼) where we observed a substantial population of bullfrogs and one or more species of pond fish.

In Scotia Canyon, bullfrogs were observed along the perennial stream segment approximately from the Peterson Ranch, down to the crossing of the AZ Trail. Another perennial segment, further down, did not have any aquatic herpetofauna nor did a small perennial stretch located just east of the Peterson Ranch. We observed two bullfrogs while surveying Garden Canyon.

Sunnyside Canyon.--An extensive system. We observed bullfrogs at the crossing of USFS RT 48 and in three tanks south and east of the old Sunnyside town site.

Sycamore Canyon.--Possibly a perennial stream. We observed small bullfrogs, canyon treefrogs, and Sonoran mud turtles. Small fishes observed were probably longfin dace.

Southeast--Bullfrogs absent

Lone Mt Canyon and Bear Creek.--These two streams have their confluence about 150 m north of RT 61. Lone Mt Canyon and the confluence appear to be perennial as indicated by the presence of longfin dace and crayfish. No riparian herpetofauna was observed in two visits this year on July 29 and August 19. We did, however, receive a report of a mountain treefrog sighted in Lone Mt Canyon earlier in 1993 (Dave Parizek, pers. com.). The UAZ collection includes specimens of the canyon treefrog, lowland leopard frog, Chiricahua leopard frog, Sonoran mud turtle, and black-necked gartersnake.

Cave Canyon.--The lower stream was dry and no riparian herpetofauna was observed.

Copper Canyon.--No riparian herpetofauna was observed here. A fully transformed specimen of the tiger salamander (*Ambystoma tigrinum stebbinsi*) was found by F. Reichenbacher on 4 August 1993 at a tank near Copper Canyon (T24S, R20E, Sec 10, center of W1/2).

HABITAT ASSESSMENT

Based on the natural history information presented for the mountain treefrog and Mexican garter snake, the critical habitats identified in Scotia Canyon are the three ponds in the immediate vicinity of Peterson Ranch and the lower pond with its associated perennial stream.

Habitat changes from 1980 to 1993.--The structural environment has changed remarkably little in thirteen years. There is some evidence of succession in the ponds. This is most obvious with the spread of large emergent plants such as cattail and bullrush. Thickets of these appear to be the most difficult areas for removing bullfrogs.

By 1993, the middle pond had become so full of bullrush that there was no open water. We did not observe any garter snakes, which had been present in 1980-1982, and only few bullfrogs. All of the ponds are artificially constructed and will eventually return to a natural cienega habitat without further intervention.

In adjacent terrestrial habitat, changes included the natural re-colonization and growth of alligator junipers in the old clearings at the Peterson Ranch. A large willow at the east end of the fenced-in pond appeared to be dying. There were three old, large cottonwood trees and only one sapling. Interestingly, some of the dead, down cottonwood limbs observed over ten years ago were still present, suggesting a slow decay rate.

Human impacts.--Motor vehicles are clearly destructive to the environment. We noticed heavy erosion, noise, and crushed animals resulting from traffic. Off-road driving is a particular problem in the open grassy areas around ponds. This habitat is frequented by bunchgrass lizards, Madrean alligator lizards, and all species of snakes.

It is unfortunate that camping is also destructive. We observed countless campfire rings and litter. We had to put out one fire that was abandoned and still smoldering. In two cases large quantities of trash were left behind by groups of campers. After reconnecting a broken water line, we found it disconnected three times, and always after a family had camped nearby.

The road just below the Peterson Ranch passes through an area of limestone soils with a spectacular population of agaves. Five meters from the road we found a six foot pry bar and several small craters where agaves had obviously been removed.

During 1993, we encountered three parties of hikers where one or more members carried a snake hook. In each case, they claimed to be photographing and releasing animals. In 1980, we met hikers with pillowcases who had collected two mountain kingsnakes. It is quite clear from the disturbance of cover sites that collecting is common in Scotia Canyon and throughout the Huachuca Mts. In 1980 and 1981, we found two blacktail rattlesnakes and an Arizona ridgenose rattlesnake that had been decapitated and hung on the gate at Peterson Ranch.

STATUS OF OTHER AQUATIC HERPETOFAUNA IN SCOTIA CANYON

Leopard frogs.--Few leopard frogs were sighted in Scotia Canyon in 1980 and 1981. They were identified as *Rana pipiens* complex at the time and none were preserved from the study site. Two specimens collected from Scotia Canyon in 1951 are in the UAZ collection (UAZ 20273 & 20294). They presently key out as the lowland leopard frog (*R. yavapaiensis*). Two other specimens from the same locality, not examined by us, are cataloged as *R. yavapaiensis* and deposited at the Los Angeles County Museum (LACM 13843-4). Two specimens of the Chiricahua leopard frog (*R.*

chiricahuensis) were collected from Sunnyside in 1960 (UAZ 19466 & 20028), a canyon adjacent to Scotia.

Peterson Ranch, at 6150 feet elevation, is higher than typical localities of the lowland leopard frog. Although perhaps ameliorated by its southwest aspect, the site may have been marginal for the species. Both leopard frog species are represented among material collected along the southwest flank of the Huachuca Mountains including Bear Canyon and Parker Canyon Lake. It is possible that both occurred in Scotia Canyon. None of the specimens is identifiable to *R. subaquavocalis*.

An argument can be made that all leopard frogs in the area were *R. chiricahuensis* and that some exhibited traits characteristic of *R. yavapaiensis*. In fact a review of 42 *R. chiricahuensis* from the type locality deposited at Arizona State University revealed five that possessed a prominent reticulate pattern on the thighs--the key character for *R. yavapaiensis*. It would seem that species definitions need to be clarified and the identification keys rewritten accordingly. In light of this we advise the reader to be open to both possibilities.

We have made no observations of any leopard frog from the southwest flank of the Huachuca Mts since 1981. The implications are somewhat alarming. We cannot attribute the leopard frog decline entirely to the spread of bullfrogs. Leopard frogs were observed in Lone Mtn and Bear Canyons until 1981 yet no bullfrogs have ever been seen there. Leopard frogs apparently disappeared from Scotia Canyon prior to the explosion of bullfrogs. Perhaps they co-occurred in low numbers prior to the explosion.

The tiger salamander.--Tiger salamanders have been present in the lower pond in Scotia Canyon at least since 1980 and perhaps much longer. We collected the first fully transformed individual in a shallow-end trap in September 1993 (UAZ 50076). Its color pattern consisted of numerous pale spots on a dark background and we have tentatively identified it as a Sonora tiger salamander, *Ambystoma tigrinum stebbinsi* (Lowe 1954, 1955). The first author had initially identified salamanders in this pond as *A. t. mavortium.*

Jones et al (1988) could not confidently identify any of their field collected adults from the San Rafael Valley as *A. t. stebbinsi.* They found that whereas all newly metamorphosed individuals (including the type series) exhibit the many-spotted *A. t. stebbinsi* pattern, further development of six months leads to either a unique reticulate or a barred adult color pattern. The pattern of newly metamorphosed *A. t. stebbinsi* is nearly identical to that of *A. rosaceum* which occurs at the southern end of the valley in the Sierra de los Ajos.

Jones et al (1988) have also found that *A. t. stebbinsi* exhibits the lowest level of allozyme variation reported for a salamander suggesting that the population went through a severe bottleneck. They also conclude that *A. t. mavortium* is a closer relative than *A. t. nebulosum* with which *A. t. stebbinsi* was lumped by Gehlbach (1965) and followed by Stebbins (1983). The lack of variation should be strong evidence that exotic tiger salamanders have not been introduced into the population (yet). Jones et al (1988) feel that it also indicates a great age for the population and that despite the difficulty in diagnosis it should by regarded as a distinct subspecies pending further investigation.

Despite the presence of bullfrogs and garter snakes, the tiger salamander population in Scotia Canyon appears to be stable. We observed salamanders in the lower pond during our investigations in 1980-1982 and again in 1993. Our intensive surveys of aquatic habitats in Scotia Canyon did not yield salamanders from anywhere other than the lower pond and only one fully transformed individual was observed suggesting that most adults may be neotenic and may rarely disperse. Another fully transformed individual (UAZ 50074) was found in 1993 by F. Reichenbacher at the tank 1/2 mile SW Eighty Spring near Copper Canyon at FS RT 61.

The genetic identity of *A. t. stebbinsi* could be compromised by interbreeding with exotic *A. t. mavortium.* Salamander populations in the San Rafael Valley should be monitored periodically to enable rapid identification and management response in the event that exotic forms are introduced. On January 1, 1989 it became prohibited to use salamanders as bait in Parker Canyon Lake (Schwalbe, 1988).

RECOMMENDATIONS FOR FUTURE MANAGEMENT AND MONITORING

1. Close the road to motor vehicle traffic from the trailhead of the AZ trail to Gate 7 (see map). There is no reason to keep this road open to public vehicles. To travel from the southwestern to

northeastern flanks of the Huachuca Mts would be accomplished more quickly and safely via Fort Huachuca to the north or Montezuma Pass to the south. There are countless alternative campsites and mountain roads available to recreational driving outside of upper Scotia Canyon. Sensitive, nongame species are particularly vulnerable in the summer when they are most active.

2. Reroute the water pipeline so that it is away from roads, trails, and campsites. Its obvious presence is too tempting to visitors who use it and leave it disconnected. An option exists to manipulate water flows on a small scale using part of the existing PVC pipeline or a similar apparatus. In future dry summers, managers may be able to avert reproductive failure in the mountain treefrog by artificially filling the ephemeral breeding pond if not sufficiently filled by July 15-20.

3. Determination of whether or not the mountain treefrog and Mexican garter snake populations are stable and likely to coexist with bullfrogs will require up to several consecutive years of monitoring. In 1993, we removed 162 bullfrogs from Scotia Canyon, representing nearly all individuals large enough to prey on other vertebrates. Many remaining bullfrogs will, however, reach large size by the summer of 1994. Complete eradication of the bullfrog would deprive the Mexican garter snake of its primary food source unless leopard frogs could be reintroduced.

Continued research and bullfrog control would be ideal to monitor the response of sensitive aquatic herpetofauna to management efforts. In the near future (i.e., 1996) we should be in a position to implement a lasting solution. The spatial structure of aquatic habitats make Scotia Canyon ideally suited for total removal of bullfrogs and restoration of native leopard frogs. Bullfrogs could be poisoned in the two ponds where they breed and they can easily be removed from other habitats. Salamanders and garter snakes could be trapped and held during the operation. Leopard frogs could be raised in large numbers in greenhouses for reintroduction immediately following bullfrog removal.

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APPENDIX A
Basic Data for the Mountain Treefrog

(All captures from Peterson Ranch Site)

No.	Date	Mass (g)	SVL (mm)
1	27-Sep-80	---	16
2	27-Sep-80	---	16
3	27-Sep-80	---	17
4	27-Sep-80	---	16
5	27-Sep-80	---	16
6	27-Sep-80	---	16
7	27-Sep-80	---	16
8	27-Sep-80	---	15
9	27-Sep-80	---	16
10	27-Sep-80	---	15
11	7-Sep-81	0.150	13
12	7-Sep-81	0.183	13
13	25-Jul-81	4.250	37
14	25-Jul-81	3.550	34
15	25-Jul-81	4.300	37
16	25-Jul-81	3.500	32
17	25-Jul-81	4.800	34
18	25-Jul-81	3.400	32
19	25-Jul-81	2.850	29
20	25-Jul-81	3.250	32
21	25-Jul-81	5.900	37
22	25-Jul-81	3.950	35
23	25-Jul-81	3.350	31
24	29-Jul-81	3.400	34
25	29-Jul-81	2.670	34
26	29-Jul-81	3.700	37
27	22-Jul-82	6.480	37
28	23-Jul-82	4.380	35
29	23-Jul-82	3.590	33
30	23-Jul-82	3.370	32
31	24-Jul-82	5.550	37
32	24-Jul-82	5.500	37
33	24-Jul-82	3.190	31
34	30-Jul-82	2.500	33
35	30-Jul-82	2.390	31
36	2-Aug-82	3.400	36
37	5-Aug-82	2.530	32
38	5-Aug-82	3.100	33
39	14-Jul-93	3.250	35

APPENDIX A Continued
Basic Data for the Mountain Treefrog

Body measurements of mountain treefrogs at different stages in the life cycle. Snout-vent and total lengths in mm, mass in g.

	Range	Mean	N
a) Eggs, stages 18 - 20			
SVL (mm)	2.2 - 3.0	2.69	8
Total (mm)	4.6 - 5.0	4.75	4
Tail/Total	0.35 - 0.43	0.389	4
b) Hatchlings, stages 22 - 25			
SVL	2.4 - 2.8	2.59	4
Total	6.0 - 6.5	6.18	4
Tail/Total	0.55 - 0.60	0.582	4
Mass (g)	0.002 - 0.003	0.0025	4
c) Larvae, stages 26 - 41			
SVL	2.6 - 14.3		
Total	6.3 - 39.6		
Tail/Total	0.53 - 0.64		
Mass	0.003 - 0.571		
d) Transforming, stages 42 - 45			
SVL	12.5 - 15.5	13.37	10
Mass	0.185 - 0.379	0.2824	10
e) Young of the year froglets			
SVL	12.5 - 17.0		12
Mass	0.15 - NA		12
f) Adult frogs			
SVL	29.0 - 37.0	33.83	27
Mass	2.39 - 6.48	3.781	27

Reference Heritage Grant Project I92063

Appendix B

Appendix C

Appendix D

Note: Contact the Arizona Game and Fish Department, Heritage Data Management System (602-789-3618) regarding information contained in these appendices.

APPENDIX E
LISTS OF COMMON AND NOTEWORTHY SPECIES

Plants	
Chihuahua pine	*Pinus leiophylla*
Mexican pinyon	*Pinus cembroides*
Apache pine	*Pinus engelmannii*
Mexican white pine	*Pinus flexilis*
Alligator juniper	*Juniperus deppeana*
Arizona oak	*Quercus arizonica*
Emory oak	*Quercus emoryi*
Silverleaf oak	*Quercus hypoleucoides*
Manzanita	*Arctostaphylos* spp.
Arizona madrone	*Arbutus arizonica*
Arizona sycamore	*Platanus wrightii*
Squawbush	*Rhus trilobata*
Woodland sumac	*Rhus choriophylla*
Silktassel	*Garrya* sp.
Moutain mahogany	*Cercocarpus betuloides*
Smooth bouvardia	*Bouvardia glaberrima*
Willow	*Salix* sp.
Buckbrush	*Ceanothus fendleri*
Cottonwood	*Populus fremontii*
Arizona walnut	*Juglans major*
Mescal	*Agave parryi* var. *huachucensis*
Golden-flowered agave	*Agave palmeri*
Yucca	*Yucca* sp.
Sotol	*Dasylirion wheeleri*
Spikerush	*Eleocharis* sp.
Bullrush	*Scirpus* sp.
Cattail	*Typa* sp.
Scouring rush	*Equisetum* sp.
Watercress	*Rorripa* sp.

Amphibians	
Tiger salamander	*Ambystoma tigrinum*
Southern spadefoot	*Scaphiopus multiplicatus*
Canyon treefrog	*Hyla arenicolor*
Mountain treefrog	*Hyla eximia*
Bullfrog	*Rana catesbeiana*
Lowland leopard frog	*Rana* cf *R. yavapaiensis*[1]

Reptiles	
Sonoran mud turtle	*Kinosternon sonoriense*
Short-horned lizard	*Phrynosoma douglassi*
Lesser earless lizard	*Holbrookia maculata*
Tree lizard	*Urosaurus ornatus*
Clark spiny lizard	*Sceloporus clarki*
Bunchgrass lizard	*Sceloporus scalaris*
Mountain spiny lizard	*Sceloporus jarrovi*

[1] Identification suspect, and probably extirpated (see text).

APPENDIX E Continued
Lists of Common and Noteworthy Species

Reptiles--Cont'd	
Sonoran spotted whiptail	*Cnemidophorus sonorae*
Madrean alligator lizard	*Gerrhonotus kingi*
Ringneck snake	*Diadophis punctatus*
Sonoran whipsnake	*Masticophis bilineatus*
Mountain patch-nosed snake	*Salvadora grahamiae*
Gopher snake	*Pituophis melanoleucus*
Sonoran mountain kingsnake	*Lampropeltis pyromelana*
Black-necked gartersnake	*Thamnophis cyrtopsis*
Mexican gartersnake	*Thamnophis eques*
Rock rattlesnake	*Crotalus lepidus*
Black-tailed rattlesnake	*Crotalus molossus*
Ridge-nosed rattlesnake	*Crotalus willardi*
Birds	
Mallard	*Anas platyrhynchos*
Zone-tailed hawk	*Buteo albonotatus*
Montezuma quail	*Crytonyx montezuma*
Turkey	*Meleagris gallopavo*
Roadrunner	*Geococcyx californicus*
Whiskered owl	*Otus trichopsis*
Great-horned owl	*Bubo virginianus*
Whip-poor-will	*Caprimulgus vociferus*
Poor-will	*Phalaenoptilus nuttalli*
Common nighthawk	*Chordeiles minor*
Black-chinned hummingbird	*Archilochus alexandri*
Elegant trogon	*Trogon elegans*
Common flicker	*Colaptes auratus*
Acorn woodpecker	*Centurus formicivorus*
Ladder-backed woodpecker	*Dendrocopos scalaris*
Sulphur-bellied flycatcher	*Myiodynastes luteiventris*
Ash-throated flycatcher	*Myiarchus cinerascens*
Black phoebe	*Sayornis nigricans*
Buff-breasted flycatcher	*Empidonax fulvifrons*
Mexican jay	*Aphelocoma ultramarina*
Common raven	*Corvus corax*
Bridled titmouse	*Parus wollweberi*
White-breasted nuthatch	*Sitta carolinensis*
Brown creeper	*Certhia familiaris*
Western bluebird	*Sialia mexicana*
Painted redstart	*Setophaga picta*
Western tanager	*Piranga ludoviciana*
Hepatic tanager	*Piranga flava*

APPENDIX E Continued
Lists of Common and Noteworthy Species

Mammals	
Opossum	*Didelphis marsupialis*
Collared peccary	*Dicotyles tajacu*
Mule deer	*Odocoileus hemionus*
White-tailed deer	*Odocoileus virginianus*
Gray fox	*Urocyon cinereoargenteus*
Black bear (scat)	*Ursus americanus*
Coati	*Nasua nasua*
Western spotted skunk	*Spilogale gracilis*
Striped skunk	*Mephitis mephitis*
Mountain lion (tracks)	*Felis concolor*
Rock squirrel	*Spermophilus variegatus*
Arizona gray squirrel	*Sciurus arizonensis*
Deer mouse	*Peromyscus maniculatus*
Yellow-nosed cotton rat	*Sigmodon ochrognathus*
Mexican woodrat	*Neotoma mexicana*
House mouse	*Mus musculus*
Eastern cottontail	*Sylvilagus floridanus*
Black-tailed jack rabbit	*Lepus californicus*